

**SACRAMENTO VALLEY CHAPTER**

**ICBO**

**RECOMMENDED GUIDELINES AND PROCEDURES**

**FOR**

**THE DESIGN AND INSPECTION OF RETAINING WALLS**

**APRIL, 1995**

## INTRODUCTION

The Sacramento Valley Chapter of ICBO has developed these guidelines and procedures for the design and inspection of retaining walls for implementation by local jurisdictions. This document is intended to bridge the gap between the Uniform Building Code requirements for retaining wall structures and accepted design practices. The following guidelines is not meant to be an analysis and design manual, but rather, to establish consistent engineering and inspection procedures among local jurisdictions.

As jurisdictions have varying geology and topography, modification to these guidelines may be needed to meet specific conditions. The building official must also, coordinate the implementation of this policy with existing ordinances and policies. However, the more closely these guidelines and procedures are followed, the more uniform the policies of each jurisdiction become. This uniformity translates into greater familiarity by all parties involved and will reduce the time an individual jurisdiction must spend explaining and enforcing its particular policy.

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## OVERVIEW

This document classifies retaining walls into one of four general categories. The document specific definitions should be read carefully before determining a retaining wall's category. Although, category "A" walls are exempt (they do not require a building permit), this document provides information that is applicable to the design and construction of all retaining walls. After the retaining wall has been categorized it's requirements can be obtained from the "requirement" table. These requirements are explained in detail following the definitions. Engineering drawings are presented at the end of the document to illustrate typical retaining wall details.

**Category A:** Retaining walls exempt from permit, are walls with an exposed wall face of (3) feet or less, and a finish grade sloping less than (5) horizontal to (1) vertical above and below the wall, and not supporting a surcharge or impounding Class I, II or III-A liquids.

Exempt retaining walls built on the property line or with in a distance equal to the exposed wall face, measured perpendicular from the property line, shall not be constructed of wood. These walls shall be constructed to also support the lateral load imposed by a (6) foot high solid fence (new or future).

**Category B:** Retaining walls with an exposed wall face greater than (3) feet and less than (10) feet that are not supporting a significant surcharge.

**Category C:** Retaining walls with an exposed wall face greater than (10) feet or supporting a significant surcharge or affected by adverse geotechnical conditions.

**Category D:** Retaining walls and retaining wall systems with unusual configuration or construction.

Requirements for the various retaining wall categories are assigned in the table and descriptions of these requirements follow the definitions below. An exempt retaining wall does not require a permit, hence, Category A has been excluded from the requirement table.

REQUIREMENTS	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
Category B				X			X	X	X	X
Category C	X		X		X		X	X	X	X
Category D	X						X	X	X	X

#### DEFINITIONS:

**Retaining wall;** Walls designed to withstand lateral earth and or fluid pressures, including any live and dead load surcharge, the self weight of the wall, and earthquake loads in accordance with accepted engineering practice. This definition also applies to free standing pool walls.

**Exposed wall face;** The vertical distance measured from the finish grade (consolidated soil or rock) at the toe of the wall to the top of the wall.

**Significant surcharges;** Lateral forces or moments acting on the wall from live, dead and earth loads as defined:

1. Backfill sloped greater than (2) horizontal to (1) vertical.

2. Lateral pressure exerted by structures founded within a horizontal distance equal to the retained height, measured from the back structural element of the wall to the foundation of the structure.
3. Vertical loads (traffic, pedestrian, snow, other live and dead) greater than 250 pounds per square foot (psf) applied within a horizontal distance equal to the retained height, measured back from the back structural element of the wall.
4. Lateral loads imposed by guardrails and solid fences greater than (6) feet in height.

**Adverse geotechnical conditions;** Unstable soils (such as landslides, thick colluvium soil layers), expansive soils, soil creep, low bearing pressure, potentially saturated soils, or as determined by the design professional or the local jurisdiction.

**Unusual configuration or construction;** Terraced or tiered walls (closer than twice the retained height), walls with multiple tiers of anchors, slopes greater than (2:1) at toe of wall, or as determined by the design professional or the local jurisdiction.

## **REQUIREMENTS:**

### **#1 Geotechnical report;**

A geotechnical report is to be prepared by a registered engineer qualified to address all applicable geotechnical issues including those listed below.

#### **General Information:**

- a. Property owner(s).
- b. General vicinity of the proposed site.
- c. Date(s) of site visit(s) and testing.
- d. Description of work performed.
- e. The engineer who is responsible for the report shall wet stamp and sign the document(s).

#### **Design Information:**

- a. On-site location(s) of proposed wall(s) (or a statement that the design parameters represent the worst anticipated soil conditions for the site).
- b. Purpose of the retaining wall (earth retention/rigid structure support).
- c. Contour lines and or slopes adjacent to wall(s).
- d. Identify fill material which represents a new loading condition on soil.
- e. Retained wall height(s).
- f. Surcharge(s) acting on wall.
- g. Location(s) of structure(s) supported by wall(s).

**Geotechnical Information:**

- a. Strength of the existing soils or rock.
  - Strength testing of soils:
    - Remolded samples appropriate for engineered backfill.
    - Undisturbed samples appropriate for retained undisturbed soil.
- b. Rock mechanics analysis.
- c. Seismic design forces acting on the wall.
- d. Groundwater condition (existing and potential), high ground water, seeps, springs, flooding, potentially saturated soils.
- e. Surface and subsurface drainage requirements and design.
- f. Identify any adverse geotechnical conditions: unstable soils (such as landslides, thick colluvium soil layers), global stability, expansive soils, soil creep.
- g. Conclusions and recommendations for grading and compaction of fill material.
- h. Design review, testing and inspection recommendations.

**Geotechnical Design Criteria:**

- a. Unit weight of the soil.
- b. Cohesion of the soil.
- c. Angle of internal friction of the soil ( $\Phi$ ).
- d. Equivalent fluid pressure.
- e. Allowable bearing pressure of the soil.
- f. Earth pressure from expansive or unstable soils.
- g. Freeze/thaw depth.
- h. Friction factor for resistance to lateral loads.
- i. Passive pressure for resistance to lateral loads.
- j. Drain rock/filter fabric requirements.
- k. Erosion protection and maintenance requirements.

**#2 Site Observation; (PROPOSED)**

A site observation, after the excavation, shall be performed by a registered engineer qualified to verify all applicable geotechnical issues including those listed below.

**General Information:**

- a. Engineer who conducted the site visit(s), this engineer shall wet stamp and sign document(s) containing site observation information.
- b. Property owner(s).
- c. General vicinity of the proposed site.
- d. Date(s) of site visit(s) and testing.

**Design Information:**

- a. On-site location(s) of proposed wall(s) (or a statement that the design parameters represent the worst anticipated soil conditions for the site).
- b. Purpose of the retaining wall (earth retention/rigid structure support).
- c. Contour lines and or slopes adjacent to wall(s).
- d. Identify fill material which represents a new loading condition on soil.
- e. Retained wall height(s).
- f. Surcharge(s) acting on wall.
- g. Location(s) of structure(s) supported by wall(s).

**Geotechnical Information:**

- a. Strength of the existing soils or rock.
- b. Rock mechanics analysis.
- c. Groundwater condition (existing and potential), high ground water, seeps, springs, potentially saturated soils.
- d. Surface and subsurface drainage requirements and design.
- e. Identify any adverse geotechnical conditions: unstable soils (such as landslides, thick colluvium soil layers), global stability, expansive soils, soil creep.
- f. Conclusions and recommendations for grading and compaction of fill material.
- g. Design review, testing and inspection recommendations.

**Geotechnical Design Criteria:**

- a. Classify material type per Uniform Building Code (UBC) TABLE NO. 29-B. Soil material properties: allowable bearing pressure (limited to 1500 psf), lateral bearing pressure (limited to 150 psf), friction coefficient (limited to 0.25).
- b. Equivalent fluid pressure.
- d. Freeze/thaw depth.
- e. Drain rock/filter fabric requirements.
- f. Erosion protection and maintenance requirements.

**#3 Settlement;**

Determine the anticipated settlement of the retained backfill supporting any structures. Address potential settlement and bearing pressure failure due to an increase of fill material and surcharge. The anticipated settlement and retaining wall design shall be submitted to the design professional of record for the structure.

The design professional of record for the structure shall define the allowable settlement(s) of that structure and review the retaining wall design, structural calculations and anticipated settlement for compliance with defined criteria. The design professional of record for the structure shall indicate on the drawings any comments and corrections or "no exceptions taken" and sign as proof of review.



**#4 Minimum Equivalent Fluid Pressure;**

In the absence of test data, **Cantilevered walls** retaining drained earth may be designed for pressures equivalent to that exerted by a fluid weighing **not less than 35 pounds per cubic foot (pcf)** and having a depth equal to that of the retained earth. Any surcharge shall be in addition to the equivalent fluid pressure. Surcharges due to sloped backfill, (2) horizontal to (1) vertical (2:1) and flatter, may be accounted for by increasing the equivalent fluid pressure to not less than shown in the table below.

Drained Earth Pressure	
Slope of backfill	Equivalent Fluid Pressure
Level	35 pcf
5:1	40 pcf
4:1	42 pcf
3:1	45 pcf
2:1	55 pcf

**Restrained walls** (buttresses or restrained near the top of the wall only) retaining drained earth may be designed using the cantilever wall pressure distribution defined above in addition to a uniform distribution, with a magnitude of (10) times the retained height ( $10 \cdot H$ ), superimposed. Any surcharges shall be in addition to this composite pressure distribution.

**Alternatively**, the lateral earth pressure imposed onto the cantilevered or restrained retaining walls may be determined from requirement #5.

**#5 Lateral earth pressure;**

Lateral earth pressure maybe determined by using Rankine (assume no wall friction or soil cohesion) or Coulomb or another approved theory. The geotechnical documents shall address the type of retaining wall(s) proposed, loading condition(s) and justification of soil parameters.

#6 Earthquake (seismic) loads; (PROPOSED)

Seismic forces shall be specifically addressed:

1. If the wall is supporting a structure or the surcharge from a structure, except structures defined by the UBC for use by group R division 3 and group M occupancies.
2. If the wall is protecting a structure, except structures defined by the UBC for use by group R division 3 and group M occupancies.
3. If the exposed wall face is over 12 feet.
4. If the wall is protecting an exit or is part of a structure defined by UBC TABLE NO. 23-K Occupancy Categories; I. Essential Facilities, II. Hazardous Facilities or III. Special Occupancy Structure.
5. If required by the design professional or the local jurisdiction.

At the discretion of the design professional, the seismic thrust may be evaluated with the pseudo-static Mononabe-Okabe equation. Walls may be designed using the following approximated values:

In seismic zone 3, the resultant seismic force =  $14H^2$  positioned  $0.6H$  above the top of the footing or base. Where "H" is the retained earth height.

In seismic zone 4, the resultant seismic force =  $18H^2$  positioned  $0.6H$  above the top of the footing or base. Where "H" is the retained earth height.

In addition, Mechanically Stabilized Earth wall designs shall include the horizontal inertia force of the reinforced fill. The Mononabe-Okabe inertia force equation may be utilized. Walls may be designed using the following approximated value:

In seismic zone 3, the inertia force =  $20HL$  positioned  $0.5H$  above the base. Where "H" is the retained earth height and "L" is the depth of reinforced fill.

In seismic zone 4, the inertia force =  $24HL$  positioned  $0.5H$  above the base. Where "H" is the retained earth height and "L" is the depth of reinforced fill.

Factors of safety against sliding and overturning failure under combined loading (seismic load included) may be reduced to 75% of the static safety factors.

Concrete retaining walls designed to resist earthquake loads shall be constructed of concrete with a strength of 3000 pounds per square inch (psi) or greater and shall require special inspection per the UBC.

#7 Analysis and design issues;

**Design Professional:** Retaining walls shall be designed by an engineer or architect registered in the State of California in accordance with the Business and Professions Code.

**Design:** Retaining walls shall be designed to withstand lateral earth and or fluid pressures, including any live and dead load surcharge, the self weight of the wall, and earthquake loads in accordance with accepted engineering practice, the UBC and all applicable ICBO reports.

**Backfill and drainage:** The backfill material directly behind the wall (12" minimum) shall be free draining, nonexpansive filter material and shall be drained by weep holes, open joints and/or French drains with a positive slope to daylight. Additional drains should be placed wherever water can be "dammed" by the constructed facilities.

**Material restriction:** Retaining walls built on the property line or within a distance equal to the exposed wall face, measured perpendicular from the property line, shall not be constructed of wood. These walls shall be designed to also support the lateral load imposed by a (6) foot high solid fence (new or future).

**Temporary shoring:** Restrained walls shall not be backfilled until restrained connection and supporting elements are completed or temporary shoring is in place. The design professional shall design and detail shoring if needed during construction.

External Stability Criteria	
Failure Mode	Factor of Safety
Soil Bearing Capacity	2.0-3.0
Sliding	1.5
Overturning	1.5
Overturning of *MSE walls	2.0
Supporting elements of a restrained wall	1.5
Global stability	1.5

\* Mechanically Stabilized Earth system

**Sliding failure mode:** Friction force and passive soil pressure shall not be combined to resist sliding unless technical justification is provided and approved. Passive soil pressure within the top 12" or above the frost line must be neglected.

#8 Engineering drawings;

Plan shall be drawn to scale with sufficient detail to describe the nature and extent of the work proposed. Provide a plan view, cross section(s) and elevation(s) (if the wall has a complex configuration with steps and or varying grid layers). Information on these drawings should be complete and legible to help facilitate the review and inspection process. These drawings shall be approved, wet stamped and signed by the design professional.

Examples of typical drawings illustrating various wall types and materials are included in the back of this document.

Typical Retaining Wall Drawings	
Drawing #1	Pictorial glossary of retaining wall types
Drawing #2	Cross section of a Category A exempt retaining wall
Drawing #3	Cross section of a restrained retaining wall constructed of reinforced concrete
Drawing #4	Cross section of a cantilevered retaining wall constructed of reinforced masonry
Drawing #5	Cross section of a gravity and Mechanically Stabilized Earth retaining wall with segmental wall face
Drawing #6	Elevation of a stepped segmental wall with grid layers
Drawing #7	Cross section of terraced wall system
Drawing #8	Plan view of retaining wall

#9 Inspections by local jurisdiction;

The following inspection schedules give an abbreviated description of the minimum required inspections for retaining walls.

Compaction testing of soil backfill (excluding self-compacting drain rock) is required per the engineer's specifications but, not less than every 24" of lift. Copies of field inspection reports (Compaction and Special Inspection) shall be provided at time of inspection by local jurisdiction. The final certification report shall be provided at time of final inspection

Reinforced Concrete Retaining Walls	
Inspection	Scope of Inspection
1st	Footing pad and size, key size, reinforcement, soil condition at toe. Discuss special inspection procedures (if applicable).
2nd	Prior to concrete pour. Wall forms and reinforcement (must be accessible). Anchor bolts and hardware placement.
3rd	Drain(s), wall waterproofing, restrained support or temporary shoring per design professional. Discuss drain rock and backfill compaction procedures.
Final	Drain to daylight. Weep holes, restrained support, erosion control, backfill compaction report, special inspection report.

Block (Masonry) Retaining Walls	
Inspection	Scope of Inspection
1st	Footing pad and size, key size, reinforcement, soil condition at toe. Discuss special inspection procedures (if applicable).
2nd	4' lift, prior to grout pour. Block, mortar joints, reinforcement and grout cells.
3rd	Top lift, prior to last grout pour. Block, mortar joints, reinforcement and grout cells. Anchor bolts and hardware placement.
4th	Drain(s). Wall waterproofing. Restrained support or temporary shoring per design professional. Discuss drain rock and backfill compaction procedures.
Final	Drain to daylight. Weep holes, restrained support, erosion control, backfill compaction report, special inspection report.

Segmental Retaining Walls	
Inspection	Scope of Inspection
1st	Footing/leveling pad. Batter (if any). Discuss Special Inspection procedures (if applicable), drain(s), and backfill compaction.
2nd	Lowest layer of grid or third course of modules. Permeable drain material. Batter. Backfill compaction report. Grid, type, length, taut.
3rd	Mid layer of grid or mid course of modules. Permeable drain material. Batter. Backfill compaction report. Grid, type, length, taut.
Final	Drain to daylight. Cap layers, batter, erosion control, backfill compaction report, special inspection report.

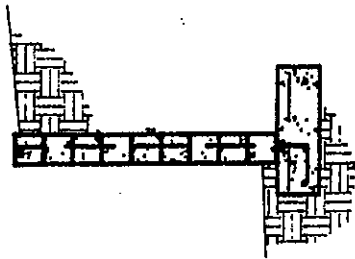
The table below is left blank for the design professional to complete for retaining walls that are not compatible with the inspection tables provided above. The "custom" inspection table is subject to local jurisdiction modification and approval.

Retaining Wall	
Inspection	Scope of Inspection
1st	
2nd	
3rd	
4th	
Final	

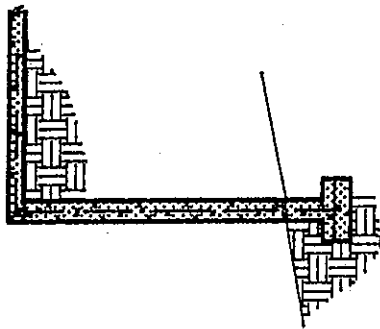
#10 Special inspection;

In addition to the above described inspections performed by the local jurisdiction's inspector the following special inspections may be required per the UBC. Inspections and testing are to be conducted by a certified inspector and qualified testing agency approved by the local jurisdiction.

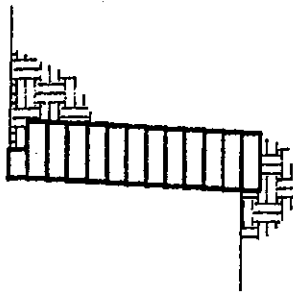
Special Inspection and Testing		
Item	Continuous	Periodic
Soil Compaction		X
Reinforced Concrete	X	
Structural Masonry	X	
Shotcrete	X	
Segmental Wall placement		X
Grids and Tie Backs		X
ICBO Report Criteria	As Spec'd	As Spec'd
Structural Observation	As Spec'd	As Spec'd



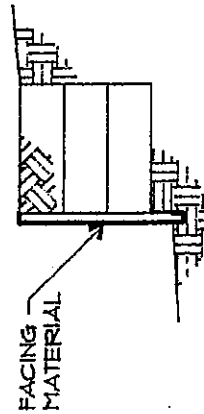
CANTILEVERED



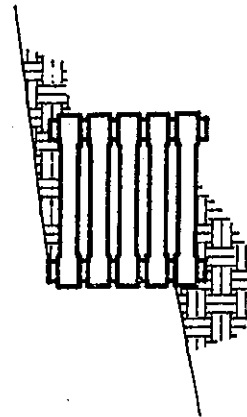
RESTRAINED



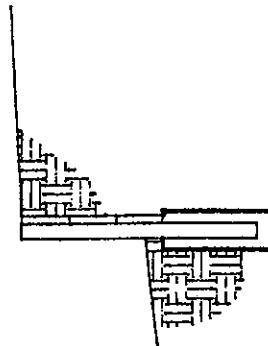
SEGMENTAL  
GRAVITY



MECHANICALLY  
STABILIZED  
EARTH



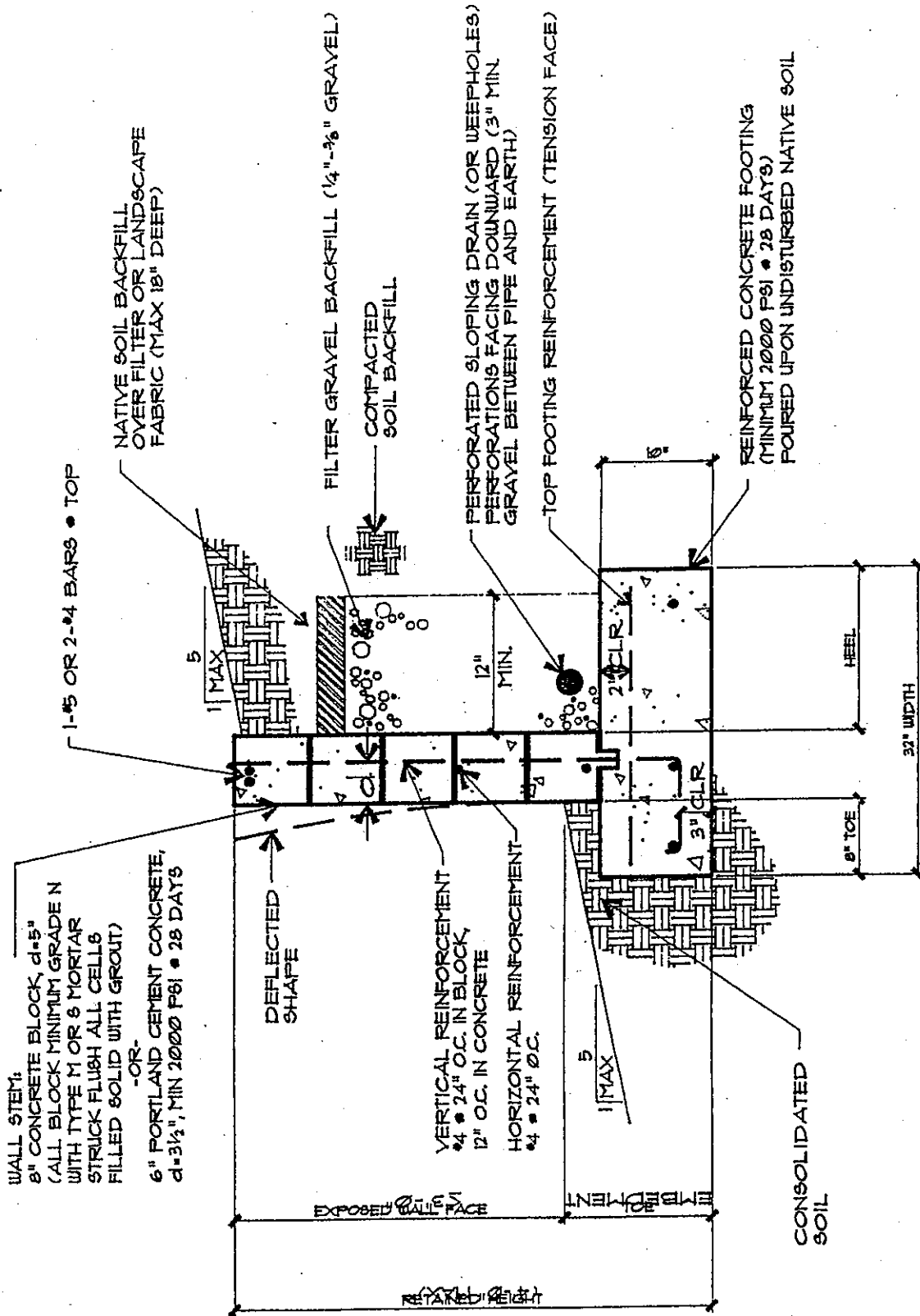
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PRESSURE PRESERVATIVE TREATED  
POST & PLANK  
(NOT ALLOWED ON PROPERTY LINES)

## DRAWING #1 PICTORIAL GLOSSARY OF RETAINING WALL TYPES

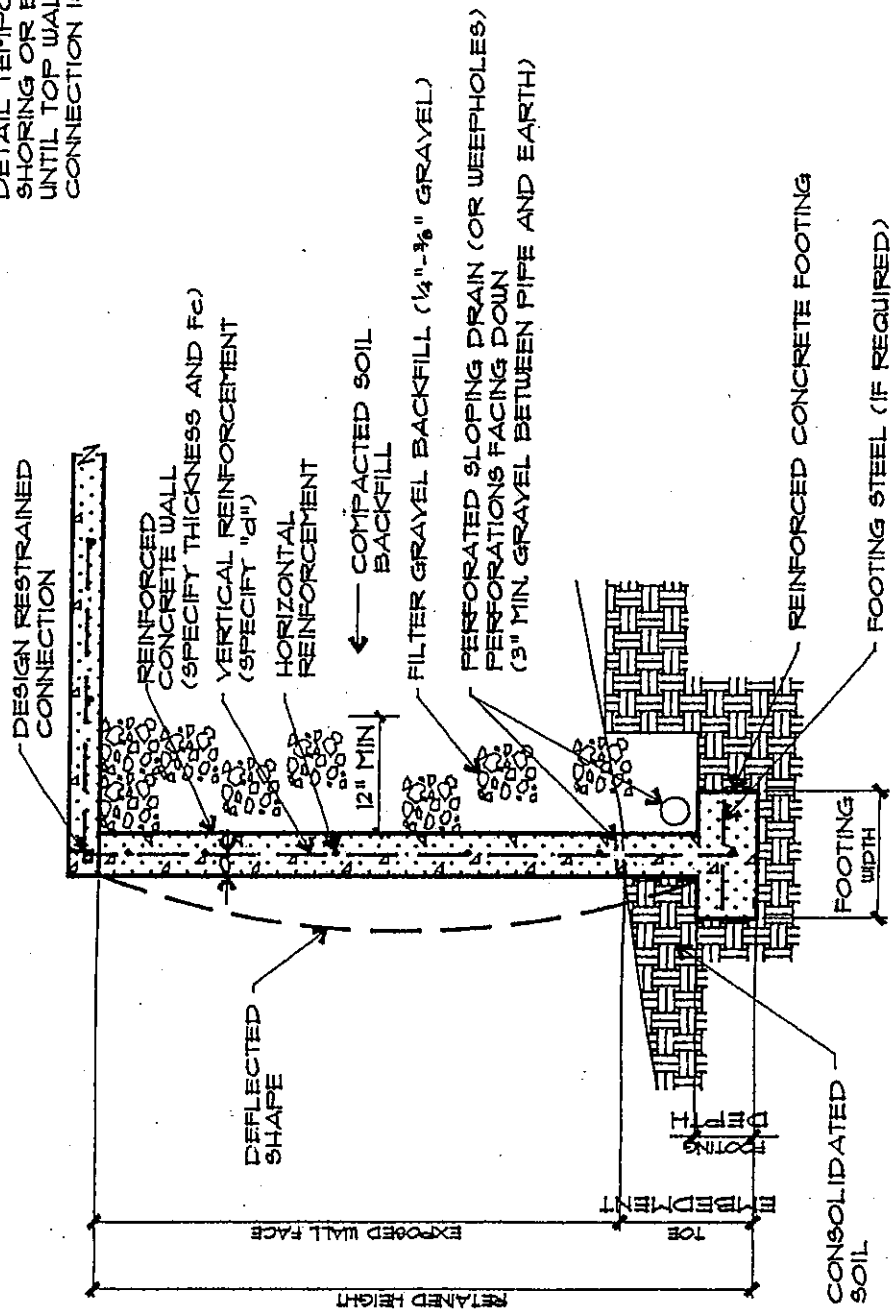




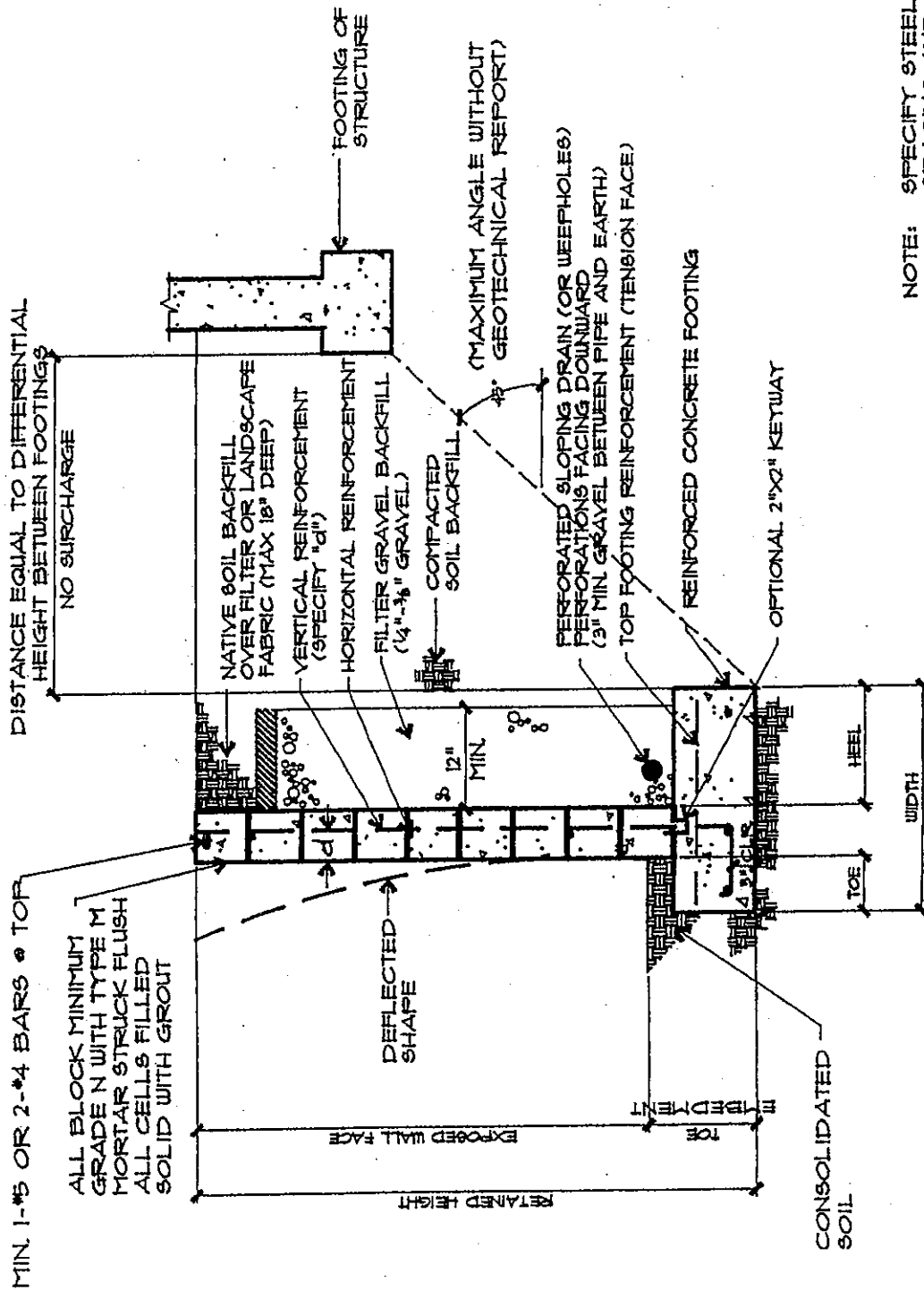
DRAWING #2  
 CATEGORY A, EXEMPT WALL

NOTE: SPECIFY STEEL SIZES,  
SPACING AND GRADE

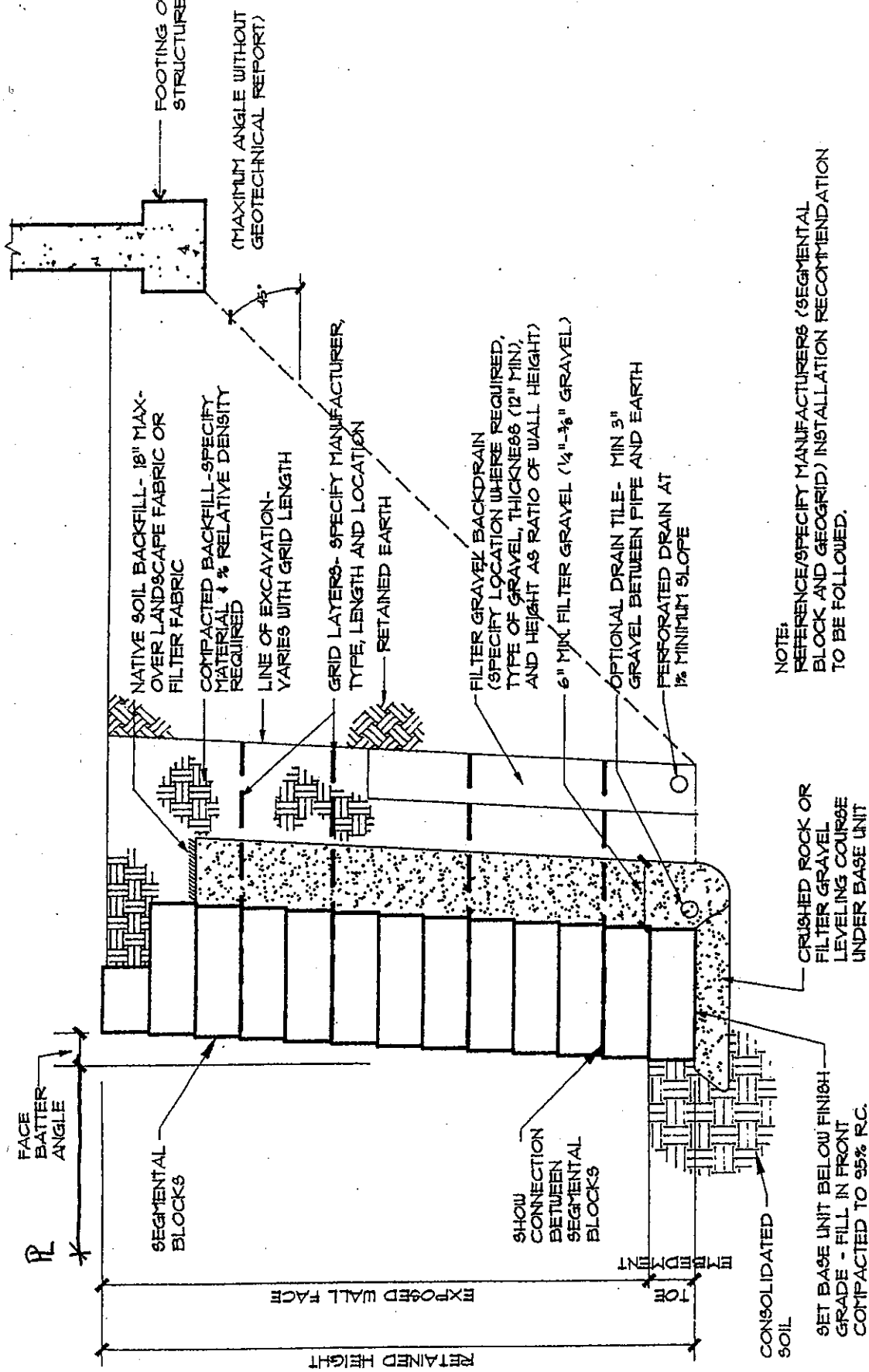
DETAIL TEMPORARY  
SHORING OR BRACING  
UNTIL TOP WALL  
CONNECTION IS IN PLACE.



# DRAWING #3 RETAINING WALL TYPE: RESTRAINED MATERIAL: REINFORCED CONCRETE



DRAWING #4  
 RETAINING WALL TYPE: CANTILEVER  
 MATERIAL: STRUCTURAL MASONRY



NOTE:  
 REFERENCE/SPECIFY MANUFACTURERS (SEGMENTAL  
 BLOCK AND GEOGRID) INSTALLATION RECOMMENDATION  
 TO BE FOLLOWED.

## DRAWING #5

# RETAINING WALL TYPE: MECHANICALLY STABILIZED EARTH WITH SEGMENTAL WALL FACE

GRID LAYERS - SPECIFY MANUFACTURER,  
TYPE, LENGTH, AND LOCATION  
(LENGTHS CHANGE WITH WALL HEIGHT)

SHOW REFERENCE ELEVATIONS  
OR DIMENSIONS AT STEPS IN WALL

SHOW LENGTHS OF STEPS  
OR STATION WALL

(ELEV)

(ELEV)

SHOW FINISH GRADE  
AT TOP BACK OF WALL  
AND FACE OF TOE

(ELEV)

ETC.

0+10

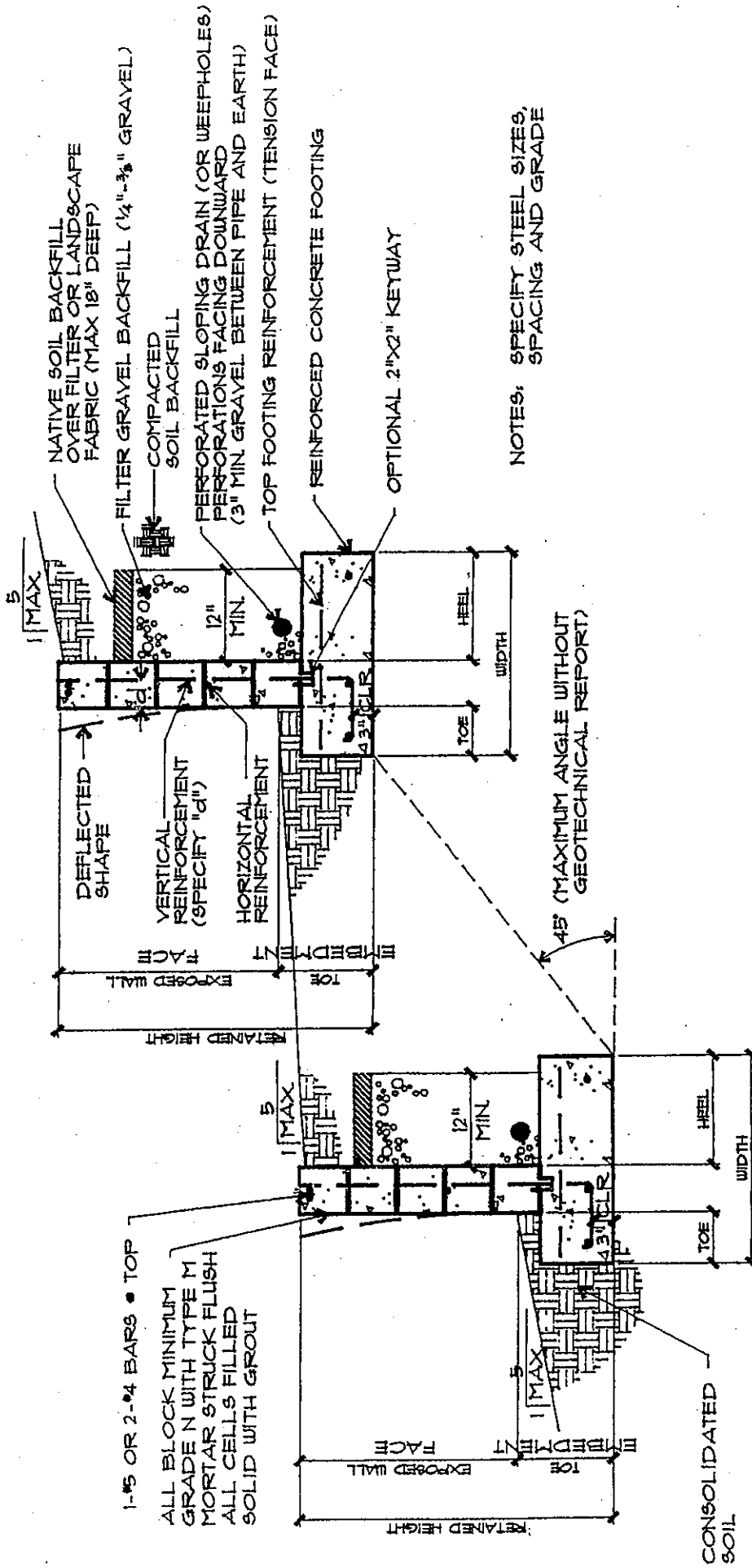
0+20

0+30

0+40

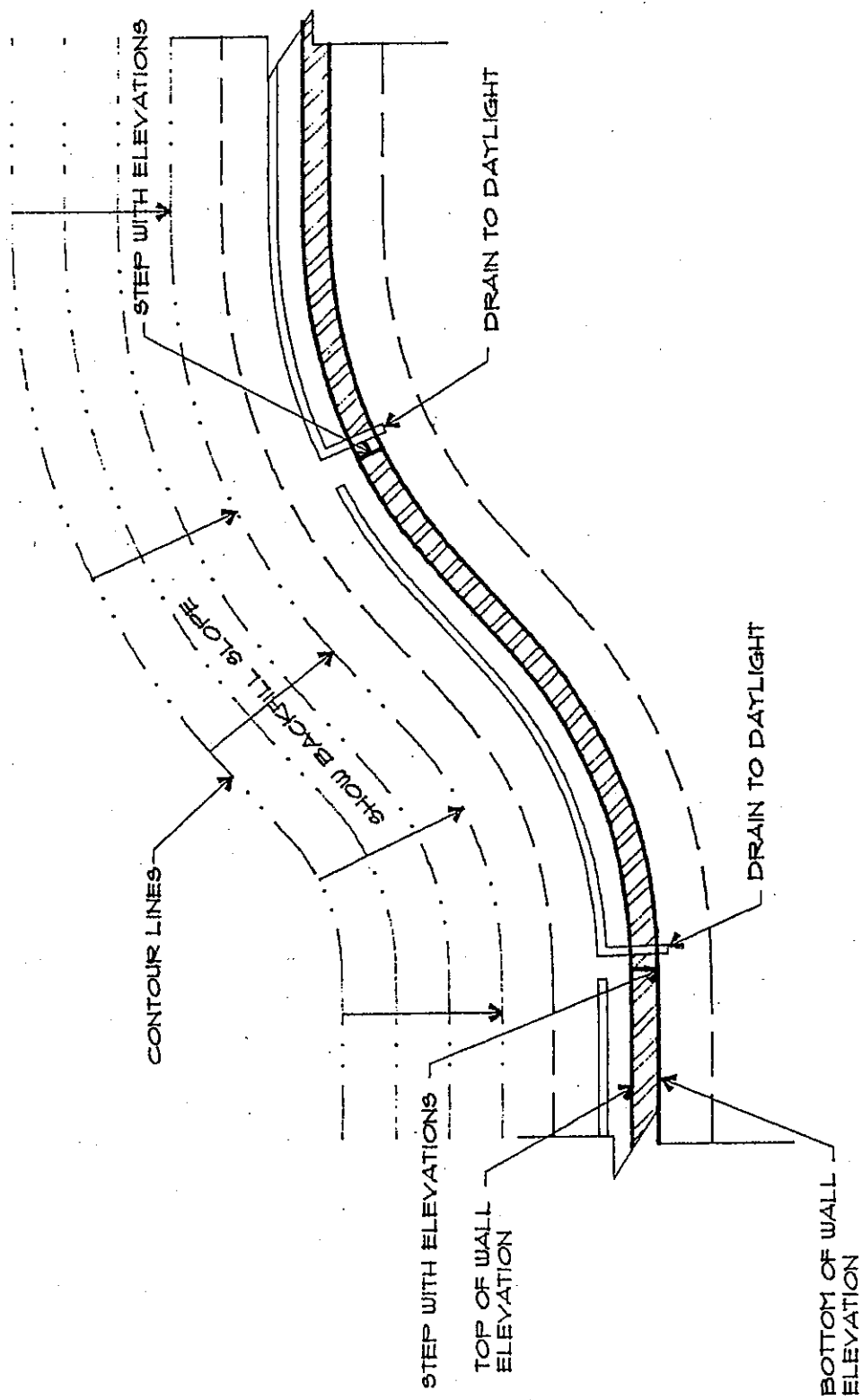
DRAWING #6

ELEVATION OF A STEPPED  
SEGMENTAL WALL WITH GRID LAYERS

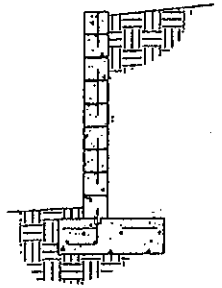


NOTES: SPECIFY STEEL SIZES, SPACING AND GRADE

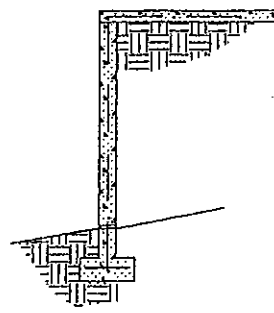
# DRAWING #7 TERRACED WALL SYSTEM



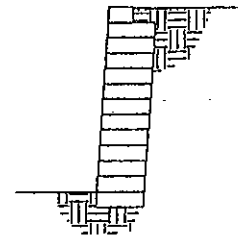
DRAWING #8  
PLAN VIEW OF RETAINING WALL



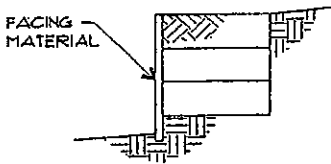
CANTILEVERED



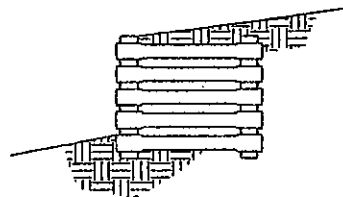
RESTRAINED



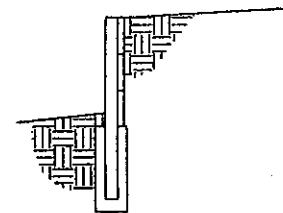
SEGMENTAL  
GRAVITY



MECHANICALLY  
STABILIZED  
EARTH

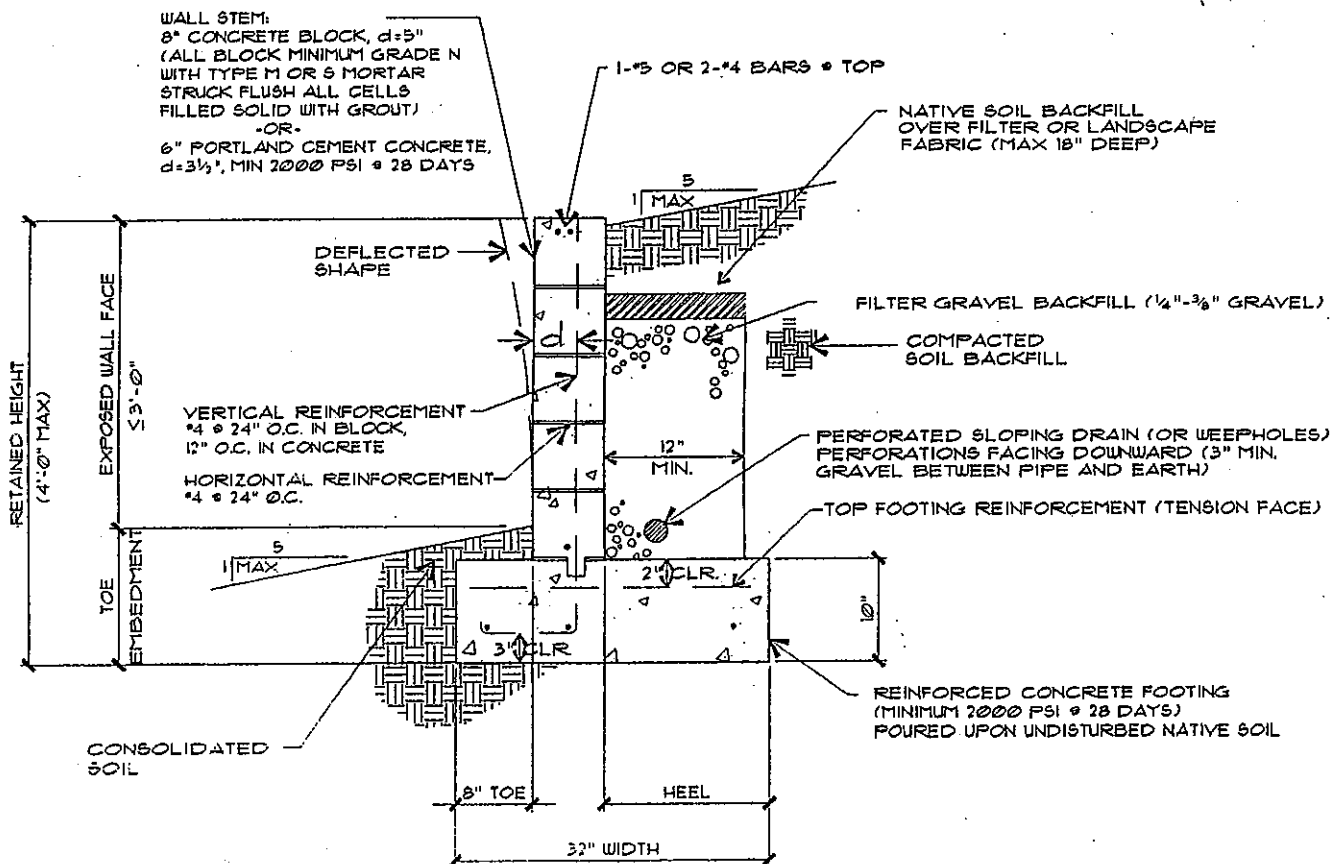


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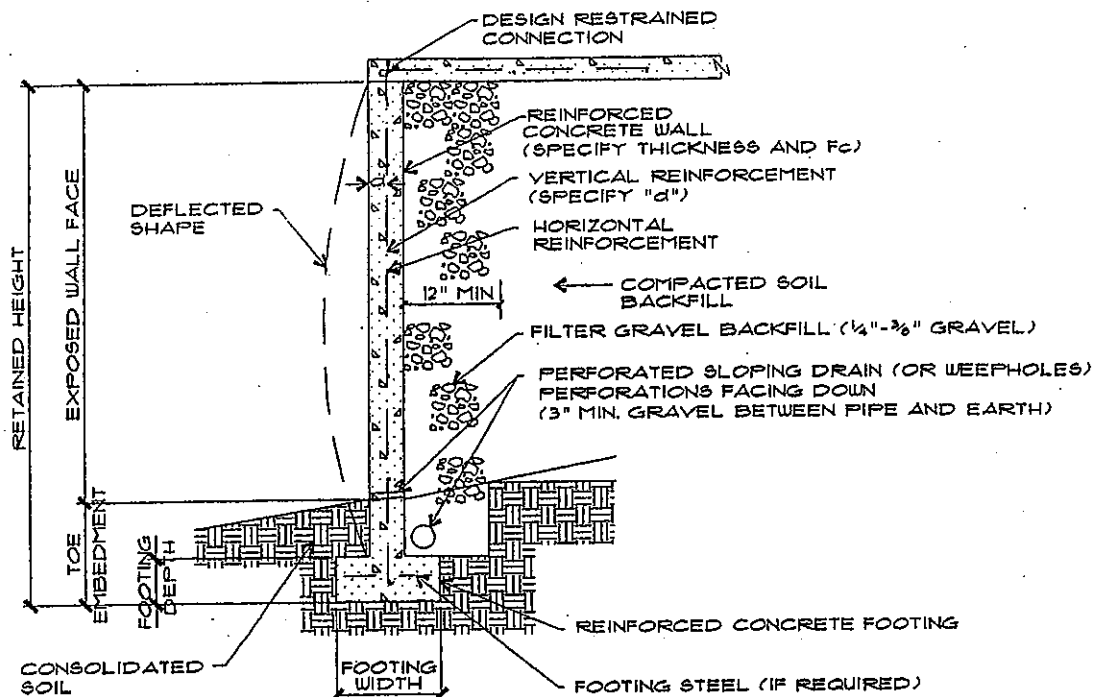
PRESSURE PRESERVATIVE TREATED  
POST & PLANK  
(NOT ALLOWED ON PROPERTY LINES)

# DRAWING #1 PICTORIAL GLOSSARY OF RETAINING WALL TYPES



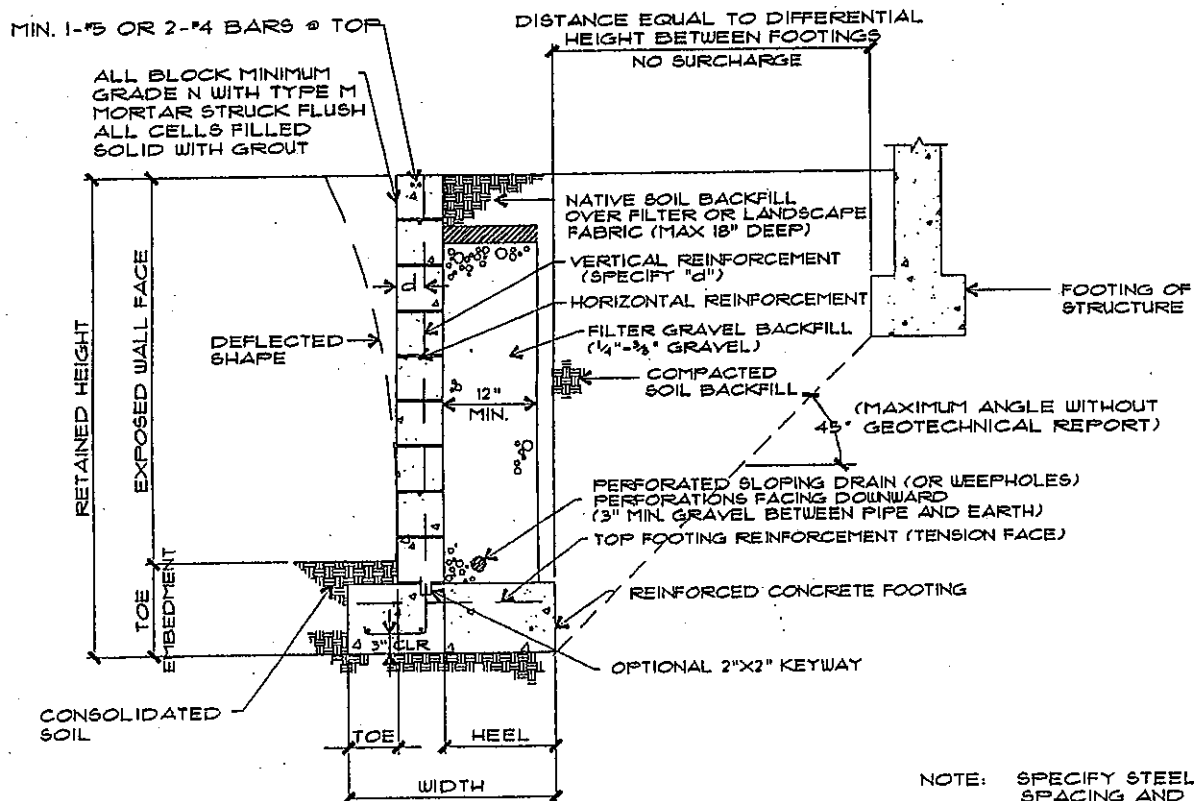
## DRAWING #2 CATEGORY A, EXEMPT WALL





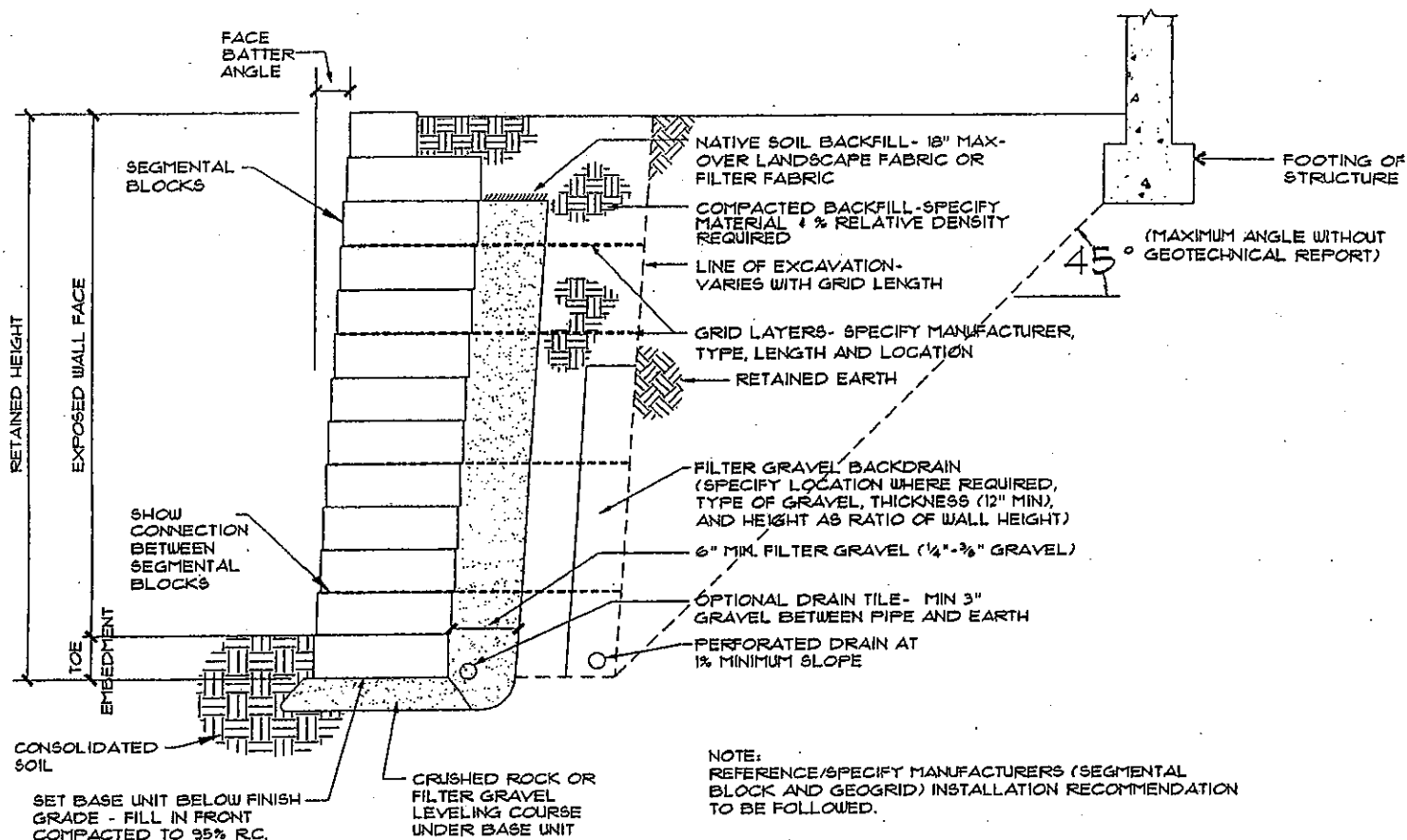
NOTE: SPECIFY STEEL SIZES, SPACING AND GRADE  
DETAIL TEMPORARY SHORING OR BRACING UNTIL TOP WALL CONNECTION IS IN PLACE.

**DRAWING #3**  
**RETAINING WALL TYPE: RESTRAINED**  
**MATERIAL: REINFORCED CONCRETE**



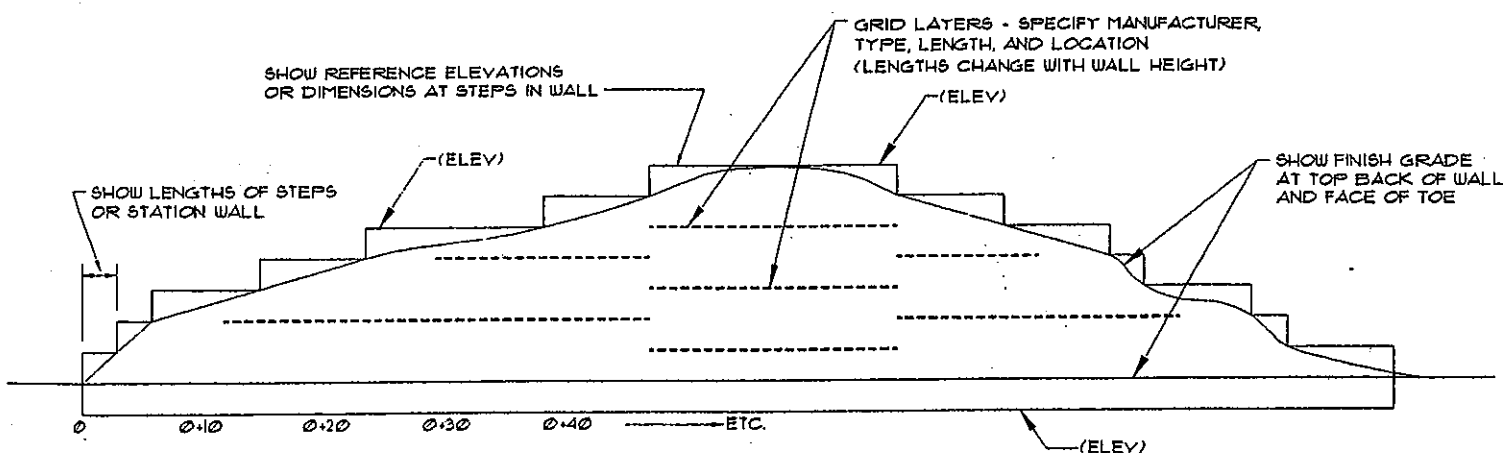
NOTE: SPECIFY STEEL SIZES, SPACING AND GRADE

**DRAWING #4**  
**RETAINING WALL TYPE: CANTILEVER**  
**MATERIAL: STRUCTURAL MASONRY**



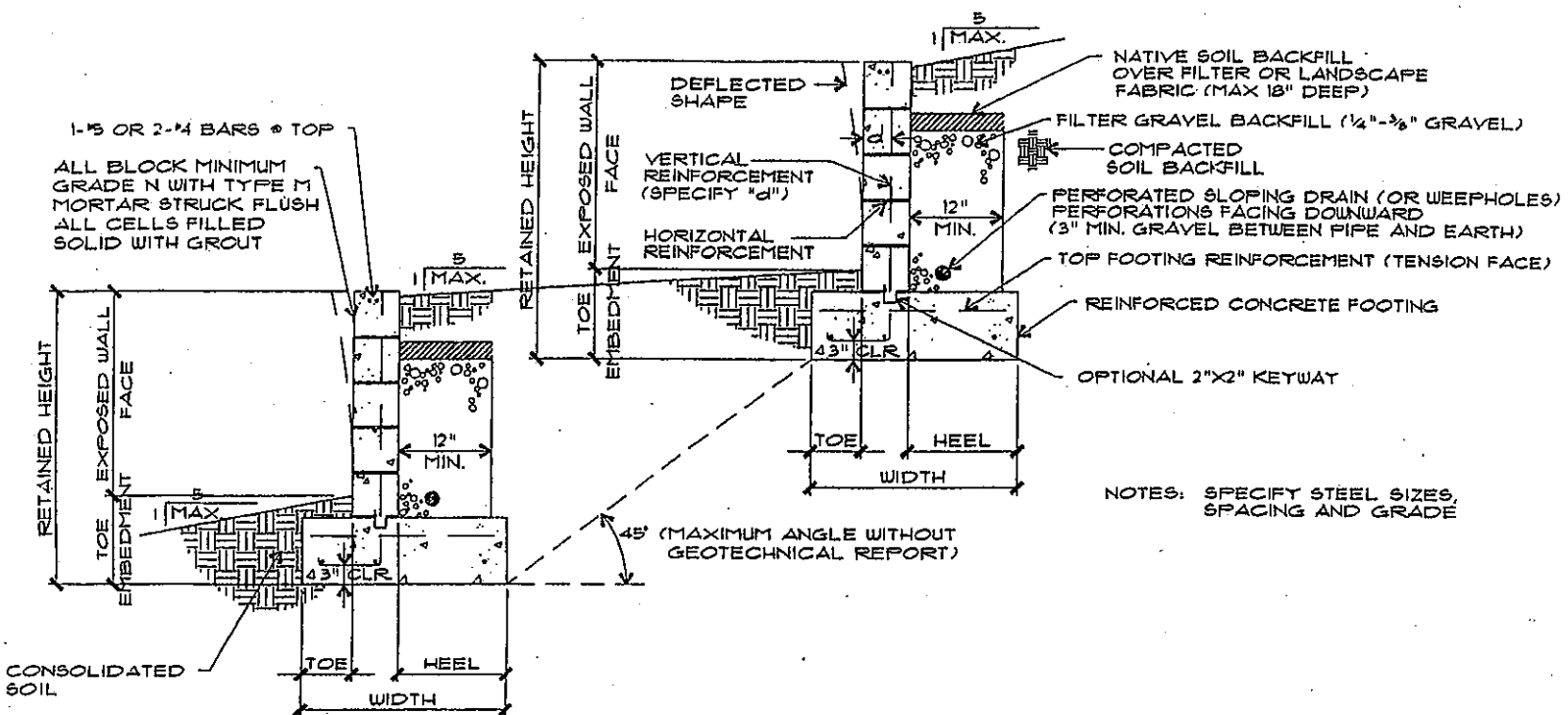
DRAWING #5

RETAINING WALL TYPE: MECHANICALLY STABILIZED EARTH WITH SEGMENTAL WALL FACE

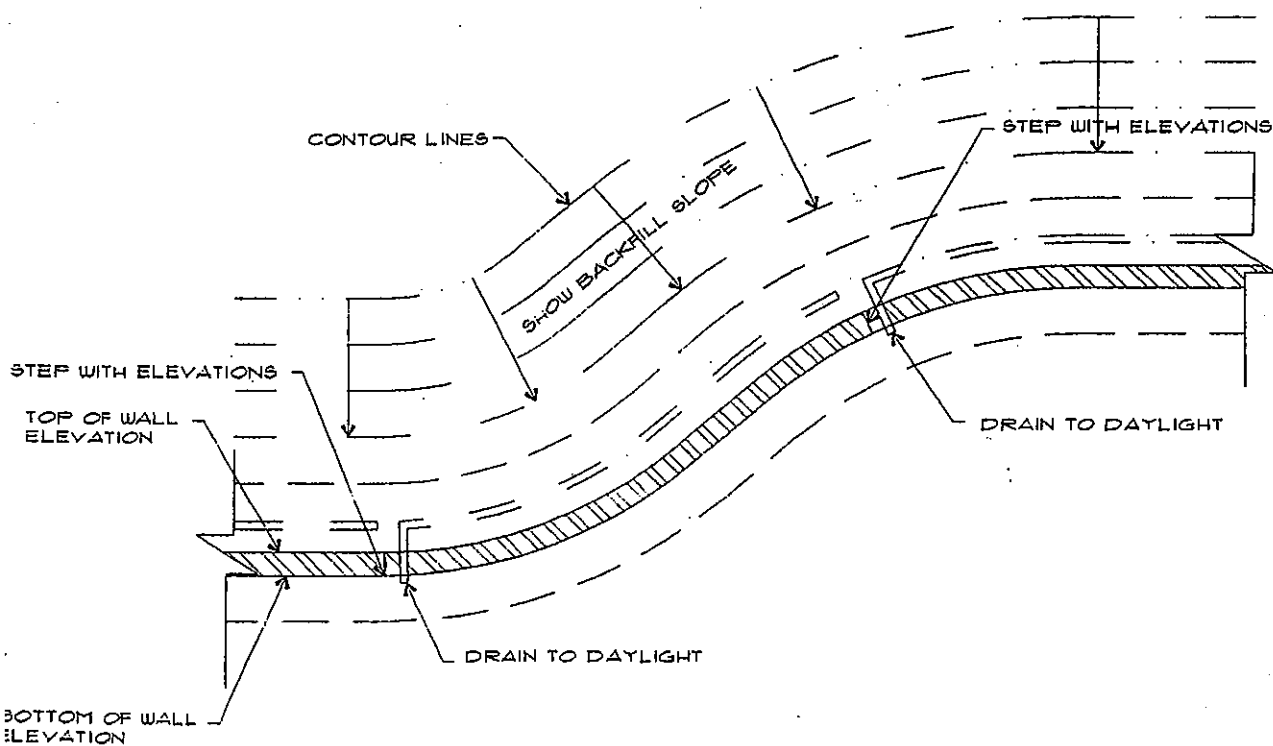


DRAWING #6

ELEVATION OF A STEPPED SEGMENTAL WALL WITH GRID LAYERS



DRAWING #1  
TERRACED WALL SYSTEM



DRAWING #8  
PLAN VIEW OF RETAINING WALL

